

IMPROVED ELASTOMERIC VALVE FOR SPILL-PROOF FEEDING DEVICES

Cross-Reference to Related Application

This application is a divisional of U.S. Application Serial Number 09/826,270, filed April 4, 2001, which is a continuation-in-part of U.S. Application Serial No. 09/475,558, filed December 30, 1999.

Field of the Invention

The present invention relates to spill-proof feeding devices, and, more particularly, to such vessels which are especially adapted for use by infants, toddlers or handicapped individuals.

Background of the Invention

Feeding devices, such as training cups, for infants, young children and the like are often provided with a cap or other closure having an apertured spout and an elastomeric valve designed for actuation by a differential pressure or through deformation. Some of these valves include a first valve member to control liquid flow out of the spout and a second valve member to control air flow into the vessel or cup (see, for instance, WIPO Publication No. WO 99/39617). The provision of two valve members is disadvantageous because it doubles the sanitation and malfunction problems and increases manufacturing costs.

In an effort to overcome the foregoing problems, elastomeric valves have been proposed which employ a single valve member. Typically, these valves employ a slitted membrane designed to control the flow of both liquid and air therethrough (see, for instance, U.S. Patent No. 5,890,621). The particular valve disclosed in U.S. Patent No. 5,890,621 is made from multiple parts, thereby complicating manufacture, assembly and cleaning. Because some of the parts are small, there is a safety problem if the valve inadvertently comes apart during use.

All of the valves described above suffer from leakage and/or spillage of liquid when there associated vessels are shaken, dropped or abruptly inverted. Such leakage and/or spillage is created by the sudden impact of liquid against the slitted valve membrane, momentarily opening the membrane to allow the unintentional passage of liquid. In the industry, this phenomenon is commonly referred to as the "trampoline" effect.

One attempt to minimize the aforementioned "trampoline" effect involves increasing the thickness and/or decreasing the area of the active valve membrane. This solution has, however, decreased the flow potential of a valve by increasing the differential pressure or deformation force required to open it, while also restricting the flow rate through the valve, thereby making it harder for a user to drink therefrom.

Another attempted solution to the "trampoline" effect problem involves encapsulating the valve in a cartridge. In the past, this solution has required a cartridge or other housing with multiple parts, resulting in a complex multi-piece assembly which is subject to the same problems as those described above in connection with U.S. Patent No. 5,890,621.

Summary of the Invention

The present invention relates to a new and improved feeding device which includes a novel drinking cup, lid and flow control valve. The feeding device, which is especially adapted for use as a trainer cup for infants, toddlers and the like, overcomes many of the problems and disadvantages associated with the prior art devices discussed above.

With respect to the new and improved drinking cup, it includes a body and an overmolding which partially covers the body. The overmolding performs a number of advantageous functions. For instance, in addition to reinforcing the body of the cup, the overmolding can be made from a softer material than the cup body, whereby it functions as a bumper or shock absorber. Even if an impact caused the cup body to crack or fracture, the overmolding would capture the resulting fragments, thereby making for a safer overall product. In one embodiment, the overmolding includes a plurality of horizontal ribs which are spaced apart in a vertical array and which extend circumferentially around the cup body. In this embodiment, the material and design of the overmolding cooperate to improve the grippability of the cup, especially when it is wet. The cup can be rendered skid resistant by applying the overmolding to the bottom surface of the cup. An attractive and unique appearance can be achieved by making the cup body from a translucent material, while making the overmolding from an opaque material. When applied to the cup body in a distinctive pattern or design, the overmolding functions as a permanent decoration.

The new and improved lid of the present invention has a spoutless design which allows a user to simulate drinking from a conventional open-mouthed cup. More

particularly, the lid includes a raised, arcuate rim formed from opposed sloping flanks which merge into a tip provided with liquid-dispensing orifices. To allow a user to drink therefrom without neck extension, the flanks cooperate with the tip to form a pocket adapted to receive the user's nose. The lid also has a receptacle for a flow control valve which is positioned in close proximity to a peripheral edge of the lid to thereby maximize liquid evacuation from an associated cup.

Turning now to the new and improved flow control valve, it has a polygonally shaped body with a plurality of corners and a liquid-dispensing nipple positioned in one of the corners. By positioning the nipple in a corner of the valve body, the flow control valve can be positioned adjacent to the peripheral edge of an associated lid, thereby promoting the foregoing objective of maximum liquid evacuation. In a preferred embodiment, the valve body has a generally triangular shape selected so as to deter its entry into the throat of a user or other individual, even upon folding or squeezing of the valve body. This safety feature can be enhanced by molding the flow control valve as a unitary or monolithic component, thereby eliminating small separate parts. Because the flow control valve is typically molded from a relatively soft and flexible material, such as silicone or some other suitable elastomer, reinforcing ribs may be applied to the valve body in order to increase its rigidity. To facilitate assembly and disassembly, the flow control valve may be provided with a handle. It is also possible to provide the flow control valve with a strap and plug combination adapted to regulate the flow of liquid through the nipple in a manner which avoids excessive pressure surges that could cause the undesired "trampoline" effect described hereinabove.

Brief Description of the Drawings

For a better understanding of the present invention, reference is made to the following detailed description of various exemplary embodiments considered in conjunction with the accompanying drawings, in which:

FIG. 1 is an exploded perspective view of a feeding device constructed in accordance with the present invention and comprised of three basic components; namely, a drinking cup, a lid and a flow control valve;

FIG. 2 is a cross-sectional view of the lid and flow control valve of FIG. 1 in an assembled state;

FIG. 3 is a perspective view, looking from below, of the flow control valve illustrated in FIGS. 1 and 2;

FIG. 4 is a front elevational view of the flow control valve illustrated in FIGS. 1 and 2;

FIG. 5 is cross-sectional view, taken along section line V-V of FIG. 4 and looking in the direction of the arrows, of the flow control valve shown in FIG. 4;

FIG. 6 is a rear elevational view of the flow control valve illustrated in FIGS. 1 and 2;

FIG. 7 is a top plan view of the flow control valve shown in FIGS. 1 and 2;

FIG. 8 is a bottom plan view of the flow control valve shown in FIGS. 1 and 2;

FIG. 9 is side elevational view of the flow control valve illustrated in FIGS. 1 and 2;

FIG. 10 is a cross-sectional view, taken along section line X-X of FIG. 9 and looking in the direction of the arrows, with the flow control valve being shown in a normal or relaxed position;

FIG. 11 is a cross-sectional view similar to FIG. 10, except that the flow is shown in a deflected position;

FIG. 12 is a perspective view, looking from below, of an alternate of the flow control valve shown in FIGS. 1-11;

FIG. 13 is a bottom plan view of the flow control valve shown in FIG. 12;

FIG. 14 is a cross-sectional view, taken along section line XIV-XIV of looking in the direction of the arrows, of the flow control valve shown in Fig. 13;

FIG. 15 is a perspective view, looking from below, of another alternate embodiment of the flow control valve shown in FIGS. 1-11;

FIG. 16 is a front elevational view of the flow control valve shown in FIG. 15;

FIG. 17 is a rear elevational view of the flow control valve shown in FIG. 15;

FIG. 18 is a side elevational view of the flow control valve shown in FIG. 15;

FIG. 19 is a bottom plan view of the flow control valve shown in FIG. 15;

FIG. 20 is a top plan view of the flow control valve shown in FIG. 15;

FIG. 21 is a cross-sectional view, taken along section line XXI-XXI of FIG. 20 and looking in the direction of the arrows, with the flow control valve being shown in a non-operating position;

FIG. 22 is cross-sectional view, taken along section line XXII-XXII of FIG. 20 and looking in the direction of the arrows, with the flow control valve in its non-operating position;

FIG. 23 is a cross-sectional view similar to FIG. 21, except that the flow control valve is shown in an operating position;

FIG. 24 is a cross-sectional view similar to FIG. 22, except that the flow control valve is shown in its operating position;

FIG. 25 is a perspective view, looking from above, of yet another alternate embodiment of the flow control valve shown in FIGS. 1-11;

FIG. 26 is a rear elevational view of the flow control valve shown in FIG. 25;

FIG. 27 is a bottom plan view of the flow control valve shown in FIG. 25;

FIG. 28 is a top plan view of the flow control valve shown in FIG. 25;

FIG. 29 is a cross-sectional view, taken along section line XXIX-XXIX of FIG. 28 and looking in the direction of the arrows, of the flow control valve shown in FIG. 28;

FIG. 30 is a perspective view, looking from below, of an alternate embodiment of the lid shown in FIGS. 1 and 2; and

FIG. 31 is a perspective view, similar to FIG. 30, showing the flow control valve of FIGS. 25-29 assembled to the lid of FIG. 30.

Detailed Description of the Exemplary Embodiments

Referring to Figures 1 and 2, a spill-proof feeding device 10 for infants, toddlers or handicapped individuals includes the following components: a drinking cup 12; a lid 14; and a flow control valve 16. Each of these components will be described in detail below.

The drinking cup 12 includes a body 18 having a bottom 20, which defines a closed end of the drinking cup 12, and an upper rim 22, which defines an open end of the drinking cup 12. The upper rim 22 of the cup body 18 is provided with external threads 24 for a purpose to be described hereinafter. The cup body 18 also includes a plurality of elongated depressions 26 in a sidewall 27 thereof, the depressions 26 being spaced at equal arcuate increments about the periphery of the sidewall 27. Each depression 26 extends upwardly from the bottom 20 of the cup body 18 toward the upper rim 22, terminating short of the external threads 24. The depressions 26 are sized, shaped, and oriented so as to provide gripping surfaces (i.e., handgrips) for the fingers and/or hands of an infant or other user of the drinking cup 12. While useful, the depressions 26 could be omitted, whereby the cup body 18 would simply have a cylindrical shape.

In a preferred embodiment, the cup body 18 is made from a thermoplastic material, such as clarified polypropylene marketed by Basell USA, Inc. of Wilmington, Delaware under the tradename PP-SR549M, which has translucent properties so that the contents of the drinking cup 12 can be viewed externally by an observer for liquid type and level identification. As used herein, the term "thermoplastic materials" is intended to mean resins, which do not possess the properties of an elastomer, that repeatedly soften when

heated and harden when cooled, Of course, any other suitable thermoplastic material having translucent properties could be used for the cup body 18, including, but not limited to, polystyrene (PS), copolymers of carboxylic acid monomers with ethylene, polystyrene-acrylonitrile (PSAN), acrylonitrile-butadiene styrene (ABS), styrene-maleicanhydride (SMA), cellulose ethers, polycarbonate (PC), polyethylene (PE), polyamides, polyethylene terephthalate, polypropylene (PP), polyvinylcyclohexane, and copolymers and blends thereof. The materials suitable for use in making the cup body 18 are typically relatively brittle, especially when cooled to below room temperature (e.g., immediately after the drinking cup 12 has been removed from a refrigerator or the like). As a result, when the cup body 18 is made from such materials, it is susceptible to breakage or cracking when dropped.

To reinforce the cup body 18, it is provided with an overmolding 28, which also performs other useful functions described below. Structurally, the overmolding 28 includes a solid base 30, which may either partially or completely cover the bottom 20 of the cup body 18, a plurality of relatively narrow, horizontal ribs 31, which extend circumferentially about the sidewall 27 of the cup body 18 at spaced intervals, and a plurality of relatively wide, vertical ribs 32, one for each of the depressions 26. The design of the overmolding 28 can be varied. For instance, the generally horizontal ribs 31 and/or the generally vertical ribs 32 can be replaced or supplemented by horizontal and/or vertical ribs having a plain shape or a particular pattern or design, such as a variety of different geometric configurations selected to impart a unique decorative look to the drinking cup 12. In order to maintain a spacing between the base 30 and an underlying support surface

(e.g., a tabletop or a countertop), the base 30 may be provided with a plurality of feet 33 (only one of which is visible in Figure 1).

The overmolding 28 may be comprised of a thermoplastic elastomer, a thermoset elastomer, a thermoset material, a thermoplastic material, or copolymers or mixtures thereof. It is preferable that the overmolding 28 be comprised of an elastomer, i.e., a thermoplastic elastomer, a thermoset elastomer, or copolymers or mixtures thereof. In a preferred embodiment of the drinking cup 12 of the present invention, the overmolding 28 is made from an engineered thermoplastic elastomer, such as vulcanized rubber marketed by Advanced Elastomer Systems of Akron, Ohio under the trademark SANTOPRENE 8271-75.

The overmolding material can be applied to the cup body 18 by any conventional bi-component molding process, including, but not limited to, two-shot injection, insert molding or co-injection molding. In addition, known conventional extrusion bonding processes, such as co-extrusion or crosshead extrusion, can be used to apply the overmolding material to the cup body 18. Conventional welding processes can also be used to apply the overmolding material to the cup body 18, including hot air welding, hot plate welding, spin welding, sonic welding or induction bonding.

In a preferred embodiment, a conventional two-shot injection bonding process is utilized wherein the cup body 18 is molded from the aforesaid PP-SR549M clarified polypropylene in a first shot injection step. Next, during a second shot injection step, the SANTOPRENE 8271-75 thermoplastic elastomer is applied and binded, and preferably fusion bonded, to the cup body 18 to form the overmolding 28. The aforesaid

two-shot injection process is a conventional process and is described in further detail in publicly available technical literature provided, for example, by Advanced Elastomer Systems of Akron, Ohio.

Because the materials used to make the overmolding 28 are generally softer than the materials used to make the cup body 18, the overmolding 28 improves the grippability of the drinking cup 12, especially when it is wet, and inhibits the drinking cup 12 from being slid along a support surface such as a counter top or table top, thereby rendering the drinking cup 12 skid resistant. In addition, the softer overmolding 28 functions as a bumper or shock absorber, thereby inhibiting breakage especially when the drinking cup 12 is cold. Even if the cup body 18 were to crack for any reason, the overmolding 28 would capture the resulting fragments, thereby making for a safer overall product. In addition, because the overmolding 28 preferably forms a bond with the cup body 18, and is thus not removable therefrom, it is not necessary to use an adhesive between the overmolding 28 and the cup body 18 during production. Moreover, due to the desirable elastomeric properties of the elastomeric overmolding 28 and its ability to effectively bond to the cup body 18, the drinking cups 12 of the present invention need only possess a single layer of elastomer in the overmolding. Although the thickness of this elastomeric layer may vary depending upon, for example, the particular elastomer chosen and the aesthetic effect desired, the thickness of the single overmolding layer may range from about 0.040 inches to about 0.125 inches, e.g., from about 0.060 inches to about 0.070 inches. Last, but not least, the overmolding 28 provides a layer of thermal insulation, which inhibits condensation from forming on the drinking cup 12, while also functioning as a

permanent decoration when it is applied to the cup body 18 in an aesthetically pleasing pattern or design.

The following discussion provides information concerning the criteria for the selection among the thermoplastic materials and/or thermoset materials that may be used to make the cup body 18 and the thermoplastic elastomers and/or thermoset elastomers that may be used to make the overmolding 28.

As used herein, the term "elastomer" shall mean all substances having the properties of natural, reclaimed, vulcanized, or synthetic rubber. The term "thermoset materials" is used herein to refer to resins that undergo chemical change during processing, as a result of exposure to pressure and temperature over time to become permanently insoluble, infusible, and hard; "thermoset materials" do not possess the properties of an elastomer. Examples of thermoset materials include, but are not limited to, polyurethanes, polyesters, phenolic materials and copolymers and mixtures thereof.

A thermoplastic elastomer is a flexible elastomer that is comprised of two or more polymers and provides substantially the same performance characteristics as thermoset rubber, for example, with respect to elongation, material softness (durometer) and tensile strength, while offering substantially the same processing benefits typically associated with traditional thermoplastic materials, e.g., the material repeatedly softens when heated and hardens when cooled. For example, thermoplastic elastomers can be used in traditional injection molding, extrusion blow molding and injection blow molding manufacturing processes and the process settings (e.g., temperature and pressure) are very close to the settings used for thermoplastic resins. There are two categories of thermoplastic

elastomers: engineered thermoplastic elastomers and soft olefins.

Engineered thermoplastic elastomers ("TPEs") are a combination of vulcanized rubber, typically an ethylene-propylene thermopolymer rubber (ethylene propylene diene monomer "EPDM"), with other polymers, such as polypropylene, to achieve performance properties, e.g., elongation, softness (durometer) and tensile strength, equivalent to those associated with traditional thermoset rubbers while processing like a thermoplastic. TPEs are also known as thermoplastic vulcanizates, elastomer alloys, and dynamic vulcanized alloys. Variation in durometer, or softness, is achieved by varying the proportion of standard polypropylene in the compound. The greater the proportion of polypropylene, the harder the elastomer, i.e., the higher the durometer value. TPEs of varying durometer (and thus of varying polypropylene content) are publicly available from commercial suppliers, such as Advanced Elastomer Systems. In a preferred embodiment, TPE used to make the overmolding 28 has a durometer of about SCA to about 80A, e.g., from about 72A to 77A.

Soft olefins ("TPOs") are non-crosslinked rubber phase styrenics (styrene-ethylene-butylene-styrene "SEBS", styrene-butadiene-styrene "SBS", or styrene block copolymers "SBC"), polyurethane elastomers ("TPUs"), copolyesters ("COPEs"), polyamide elastomers (polyether block polyamides "PEBAs") and copolymers and mixtures thereof. Variation in durometer, or softness, is achieved by varying the proportion of mineral oil in the compound. The added advantage of TPOs is that a wider range of material softness and material clarity is available. For example, the TPOs manufactured by and available from GLS Corporation, of McHenry, Illinois, range from a very soft 3A

durometer (almost gel like) to a harder 90A durometer. In comparison, SANTOPRENE TPE, available from Advanced Elastomer Systems of Akron, Ohio, is not available having softness values of less than 35A durometer.

Both of the foregoing categories of thermoplastic elastomers (i.e., TPEs and TPOs) can be used to bond to themselves or other thermoplastic materials such as polystyrene (PS), polystyrene-acrylonitrile (PSAN), acrylonitrile-butadiene-styrene (ABS), styrenemaleicanhydride (SMA), polycarbonate (PC), polyethylene (PE), polyethylene terephthalate, polypropylene (PP), polyvinylcyclohexane and many other resins and blends thereof. The selection between TPEs and TPOs depends upon the characteristics desired in the finished product. For example, engineered TPEs are preferred where achieving better heat stability and slightly higher strength properties are deemed important. TPOs, on the other hand, are preferred where softer durometer is desired and/or the product design requires a clear material.

Thermoset elastomers are elastomers that undergo chemical change during processing, as a result of exposure to pressure and temperature over time to become permanently insoluble and infusible. If excessive heat is added to a thermoset elastomer after cross-linking is complete, the elastomer degrades rather than melts. Examples of thermoset elastomers are natural and synthetic rubbers such as latex, nitrile, millable polyurethane, silicone, butyl, EPDM and neoprene, which attain their properties through vulcanization. While thermoset elastomers can be used in some two-shot injection applications, the strength of the bond obtained between the thermoset elastomer of the overmolding 28 and the thermoplastic material of the cup body 18, such as polypropylene,

is relatively inferior in comparison to the fusion bond created between a thermoplastic elastomer and polypropylene, the preferred thermoplastic material for the cup body 18.

Multi-component material drinking cups can be manufactured by using any thermoplastic or thermoset elastomer in combination with any rigid or semi-rigid material, either thermoplastic or thermoset, by selecting the bonding process that provides the adhesion characteristics desired for the particular application. The level of adhesion achieved between materials depends on the combination of the particular materials used and the bonding process selected. The preferred level of adhesion for the present invention is provided by a fusion bond being formed between the elastomeric overmolding and the substrate thermoplastic material.

More particularly, a fusion bond is a cohesive bond between two materials wherein intermolecular interaction has occurred, at least to some degree, at the interface between the two materials, forming an interphase therebetween that is comprised of some of each material. In order for fusion bonding to occur, it is required that the two materials be chemically compatible and that they melt at approximately the same temperature. For example, the PP-5R549M polypropylene and the SANTOPRENE 8271-75 thermoplastic elastomer, mentioned above, satisfy the foregoing requirements. There are many degrees of fusion bonding, which can be tested and quantified through conventional tensile testing. For example, as will be discussed further hereinafter, in connection with the present invention, one indicator that a fusion bond has been achieved is where there is a cohesive failure, i.e., tearing or ripping, of the elastomeric overmolding 28 prior to its separation from the polypropylene cup body 18.

Commercial suppliers of TPE and TPO provide recommendations for matching the proper grade of elastomer product (e.g., to be used for the overmolding 28) to the specific substrate thermoplastic resin being used (e.g., for the cup body 18) to achieve a bond. The following recommendations are provided by GLS Corporation of McHenry, Illinois, for matching GLS Corporation's TPO products to specific substrate thermoplastic resins.

Substrate Thermoplastic Resin	GLS Thermoplastic Elastomer (TPO)
Polypropylene(PP)	Dynaflex
Polyethylene(PE)	G2780, D2109
Polystyrene(PS)/HIPS	D3200 series
ABS	OM1040, OM1060, OM1262
Propionate	OM2040, OM2060
Copolyester	OM2040, OM2060

For thermoplastic elastomers that are commercially available from Advanced Elastomer Systems of Akron, Ohio, a satisfactory fusion bond is achieved using the SANTOPRENE 8000 series TPE and VYRAM grades PTE for the overmolding 28 on a cup body 18 that is made of polypropylene, polyethylene or nylon resins substrates.

TPEs achieve a preferable fusion bond when polypropylene resin is used for the substrate thermoplastic material since most TPEs are polypropylene based. The preferable bond strength may be achieved when the TPE overmolding 28 fatigues, fails and tears, before it can be pulled away from the substrate thermoplastic material, i.e., away from the cup body 18, during tensile testing. Such fatigue, failure and tearing of the TPE

overmolding 28 indicates that the fusion bond between the TPE and the substrate thermoplastic material is greater than the tensile strength of the TPE. However, the actual bond strength value will differ depending on, for example, the TPE grade, substrate resin selected, and process conditions. More particularly, with respect to the present invention, it is preferred that a fusion bond be achieved which has a bond strength that is equal to or greater than the tensile strength of the particular overmolding material that is selected. In this regard, it should be noted that the softer the TPE or TPO selected, the lower its durometer value, and thus the weaker the bond between the substrate thermoplastic material and the TPE or TPO.

For example, as discussed above in a preferred embodiment of the present invention, SANTOPRENE 8271 -75, a TPE product available from Advanced Elastomer Systems, is overmolded onto a cup body 18 made of clarified polypropylene marketed as PP-5R549M by Basell USA, Inc. These particular materials have been found to offer the preferred bonding characteristics, while meeting the durability and safety requirements of the present invention. The bond strength between these two particular materials is greater than the tensile strength of the thermoplastic elastomer. Thus, the thermoplastic elastomer fails (i.e., fatigues or tears) before the fusion bond between the two materials fails. These circumstances represent a preferable fusion bond between the two materials.

As mentioned above, in a preferred embodiment of the present invention, a conventional two-shot molding process may be utilized to form the cup body 18 and apply the overmolding 28 thereto. Such a two-shot molding process can be performed using a single machine with two independent injection units, each of which dispenses a different

material. Alternatively, two separate conventional molding machines may be used along with a rotating table to supply parts from one machine to another in a step intermediate to the first and second shot steps of the process.

In a preferred embodiment of the present invention, a commercially available Engel 330 Ton bi-component injection-molding machine with a robotic arm transfer may be used to perform the two-shot molding process. The molding machine includes a first shot molding cavity with an associated primary runner system, a second shot molding cavity with an associated secondary runner system and a robotic arm to transfer the molded cup body 18 from the first shot molding cavity to the second shot cavity for application of the overmolding 28 thereto. In this embodiment, the cup body 18 is formed during a first shot molding step, wherein the first shot molding cavity is closed and the first material (i.e., a substrate thermoplastic material such as polypropylene) is shot through a primary runner system, as in conventional molding processes, to fill the first shot molding cavity and then allowed to cool. The injection pressure under which the substrate thermoplastic material (i.e., the polypropylene) is shot into the first shot molding cavity should be between 1,000-1,200 pounds per square inch ("psi"). The injection temperature of the substrate thermoplastic material should be between 400-420 degrees Fahrenheit ("°F"). The cooling time for the molded polypropylene cup body 18 in the first shot molding cavity is approximately 6-10 seconds. Next, the first shot molding cavity opens and a robot removes the molded polypropylene cup body 18 from the first shot molding cavity and inserts it into a second shot molding cavity, whereupon the second shot cavity closes. It should be noted that the temperature of the molded polypropylene cup body 18

must be hot to the touch, i.e., 100-160°F, to achieve a preferable fusion bond with the TPE during the second shot molding step.

The overmolding 28 is then applied to the cup body 18 during the second shot step of this embodiment. In particular, the second shot molding cavity is closed and the overmolding material (i.e., TPE) is shot through the secondary runner system in a conventional manner and is molded into the overmolding 28. The injection pressure under which the TPE is shot into the second shot molding cavity should be between 400 psi and 1,800 psi, and preferably between 1,000 psi and 1,400 psi. The holding pressure for the TPE during this second shot step of the process should be between 400 psi and 1,800 psi, and preferably between 800 psi and 1,000 psi. The injection temperature of the TPE should be between 300°F and 450°F, and preferably between 350-370°F. Lastly, the overmolded drinking cup 12 with the TPE overmolding 28 is allowed to cool for approximately 1-20 seconds, and preferably for 3-7 seconds. After sufficient cooling, the second shot molding cavity opens and the drinking cup 12 is ejected therefrom.

The factors affecting the quality of the TPE-polypropylene fusion bond that results from the foregoing two-shot molding process depends upon a number of factors, including, but not limited to, the injection and hold pressure under which the TPE is processed during molding, the injection temperature of the TPE, the hold/cooling time of the TPE during the second shot process step, and the temperature of the substrate thermoplastic material of the cup body 18. The preferred ranges for these operating conditions have been provided above.

By selecting a polypropylene based thermoplastic elastomer (such as SANTOPRENE 8271-75 mentioned above) for the overmolding 28, and a polypropylene resin (such as PP-SRS49M also mentioned above) for the cup body 18, and by using a two-shot injection molding process with the appropriate process operating conditions, an effective fusion bond is achieved between the overmolding 28 and the cup body 18. Ideally, the fusion bond between the TPE overmolding 28 and the polypropylene cup body 18 is stronger than the tensile strength of the TPE alone, i.e., the TPE will fatigue or tear before the fusion bond fails.

The remaining components of the spill-proof feeding device 10 according to the present invention will now be described in further detail. The lid 14 includes a raised, arcuate rim 34 formed from opposed sloping flanks 36 which merge into a tip 38 provided with orifices 40 designed to permit fluid flow therethrough in a manner to be described hereinafter. The provision of the flanks 36 impart a basically spoutless design to the lid 14, while the size and shape of the entire rim 34 are specifically selected to allow a user to simulate drinking from a conventional open-mouthed cup. It should be noted, in this regard, that the flanks 36 cooperate with the tip 38 to form a pocket (P) adapted to receive the user's nose (see Figure 2).

With particular reference to Figure 2, the lid 14 also includes a circular skirt 42 which is provided with internal threads 44 adapted to threadedly engage the external threads 24 on the upper rim 22 of the cup body 18, whereby the lid 14 can be removably applied to the drinking cup 12. A circular sealing ring 46 is positioned within the lid 14 in close proximity to the skirt 42. The skirt 42 and the sealing ring 46 are arranged

concentrically so that they can perform a function which will be described hereinafter.

An internal, tubular sleeve 48 extends below the orifices 40, terminating in a lower edge 50. The sleeve 48 forms a generally cylindrical socket 52 having a size and shape selected so as to releasably receive the flow control valve 16 in a manner which will be described in greater detail below. It should be noted that the sleeve 48 actually merges into, i.e., is integral with, the sealing ring 46 (i.e., there is no space between the sleeve 48 and the sealing ring 46), whereby the sleeve 48 is located in close proximity to the periphery of the lid 14 as defined by the skirt 42. Unlike prior art drinking cups, which employ lids having sleeves that are not merged with their sealing rings, the drinking cups of the present invention beneficially provide the users with the ability to imbibe substantially all of the cups' contents as a result of employing a lid having a sleeve 48 that is merged with its sealing ring 46.

The lid 14 is preferably made from polyethylene or any other suitable material. Unlike the cup body 18, the lid 14 is preferably opaque so that the flow control valve 16 will not be visible through the lid 14 when it is applied to the drinking cup 12.

In its most basic form as shown in Figures 1-11, the flow control valve 16 includes a generally triangular-shaped body 54 with a substantially flat upper surface 56 and a substantially flat lower surface 58. A fin-like handle 60 extends from the lower surface 58 of the valve body 54. Linear ribs 62 extend outwardly from opposite sides of the handle 60 for a purpose to be described hereinafter.

A nipple 64 projects from the upper surface 56 of the valve body 16 in the vicinity of one of its rounded apices. The nipple 64 has a lower, thick-walled section 66 and

an upper, thin-walled section 68, which is separated from the lower section 66 by an annular inclined shoulder 70. Both of the sections 66, 68 have truncated, conical shapes such that they taper upwardly away from the upper surface 56 of the valve body 16.

The outer diameter and taper of the lower section 66 are specifically selected so as to form a fluid-tight seal when the nipple 64 is inserted into the socket 52 of the lid 14. The upper section 68 is tapered in order to facilitate manufacture and assembly, as will be described in greater detail below.

The upper section 68 of the nipple 64 includes a circular diaphragm 72, which is provided with a slit 74 (see, for instance, Figures 2, 5, 7, 8, 10 and 11) along a diameter thereof so that fluid can flow through the nipple 64 in a manner to be described hereinafter. For reasons which will also be described hereinafter, in one embodiment of the present invention, the central region of the diaphragm 72 has a greater thickness than the remainder of the diaphragm 72. In this embodiment, in its normal (i.e., relaxed) state or position, the diaphragm 72 is convex relative to the valve body 54 and the slit 74 is closed (see Figure 10). Upon deflection of the diaphragm 72 in a direction away from the valve body 54, the slit 74 opens so as to communicate with a passageway 76 which extends through the valve body 54 and the nipple 64 (see Figure 11).

The flow control valve 16 is preferably molded from silicone or any other suitable elastomer, either a thermoplastic or a thermoset. While such materials render the flow control valve 16 quite flexible, the size, shape, and rigidity of the valve body 16 are specifically selected so as to inhibit entry into the throat of an infant or other user, even upon folding or squeezing of the valve body 16.

In order to assemble the feeding device 10, the handle 60 of the flow control valve 16 would be gripped between the thumb and forefinger of an individual, who would then insert the nipple 64 into the socket 52 of the lid 14 until the upper surface 56 of the valve body 54 engages the lower edge 50 of the internal sleeve 48. It should be noted that the ribs 62 make the handle 60 easier to grip, while the tapers on the lower and upper sections 66, 68 of the nipple 64 facilitate insertion into the socket 52. As indicated above, the tapered lower section 66 of the nipple 64 also forms a fluid-tight seal when it is fully seated in the socket 52, thereby inhibiting air or liquid to bypass the passageway 76 by flowing around the nipple 64 rather than through it. Because the shoulder 70 and the upper section 68 do not come into contact with the walls of the socket 52, the diaphragm 72 is isolated from any forces applied to the nipple 64 when it is seated in the socket 52 of the lid 14. Such isolation of the diaphragm 72 ensures that the slit 74 will not be opened inadvertently.

Before or after the insertion of the flow control valve 16 into the lid 14, the drinking cup 12 is filled with a desired amount of liquid. Thereafter, the lid 14 is manually screwed on to the upper rim 22 of the cup 12. When the lid 14 has been completely tightened, its skirt 42 and sealing ring 46 sealingly capture the upper rim 22 of the drinking cup 12 therebetween, thereby inhibiting leakage of liquid through the threaded joint formed by the threads 24, 44. The feeding device 10 is now ready to dispense the liquid to a user.

In use, the feeding device 10 is gripped by a user or an attendant and then lifted until the tip 38 is placed in the user's mouth. As indicated above, the depressions 26 make the cup body 18 easier to grip, especially when the user is an infant or a handicapped

individual. Tilting of the drinking cup 12 causes the liquid contained in the cup body 18 to flow into the passageway 76 of the nipple 64. When the user then creates a negative pressure within the internal sleeve 48, such as by sucking through the orifices 40, the liquid is drawn against the diaphragm 72, thereby moving the diaphragm 72 from its normal position, in which the slit 74 is closed, to a deflected position, in which the slit 74 is open. The decreased thickness of the diaphragm 72 at its outer extremity (see Figure 11) promotes the proper and complete opening of the slit 74. As long as the slit 74 remains open, liquid can flow through the passageway 76 in the nipple 64 and then out the lid 14 through the orifices 40 in the tip 38. The location of the nipple 64 and the orifices 40 in close proximity to the extremities of the drinking cup 12 and the lid 14, respectively, allows maximum evacuation of the liquid from the feeding device 10.

When the differential pressure acting of the valve drops to a predetermined level, the diaphragm 72 automatically returns to its normal or relaxed position, thereby closing the slit 74 and preventing any further flow of liquid through the nipple 64. Air is, however, allowed to be drawn back into the nipple 64 through the slit 74 in order to equalize any pressure differential occurring within the drinking cup 12 as a result of the liquid dispensing operation described above. In the event that liquid is trapped in the internal sleeve 48 between the orifices 40 and the diaphragm 72, the trapped liquid flows back into the nipple 64 along with the air. Sealing of the slit 74 is promoted by the increased thickness of the diaphragm 72 in the vicinity of the slit 74 (see Figure 10). It is noted that, in an alternative embodiment, the diaphragm 72 may be of substantially uniform thickness and have a straight or flat, rather than concave, shape relative to the valve body

54.

At the conclusion of a dispensing operation, the lid 14 can be unscrewed from the drinking cup 12 to allow for easy cleaning of the individual components. Cleaning is further facilitated by removing the flow control valve 16 from the lid 14 and cleaning these components individually. Removal of the flow control valve 16 can be accomplished quickly and efficiently by simply gripping the handle 60 as described above and then pulling on it until the nipple 64 of the flow control valve 16 is dislodged from the socket 52 of the lid 14. After all of the individual components have been properly cleaned, the feeding device 10 can be reassembled as described above in preparation for another dispensing operation.

Each individual component of the feeding device 10 can be replaced by similar or different components. For instance, the lid 14 can receive various different flow control valves. One alternate flow control valve is shown in Figures 12-14, while other alternate flow control valves are shown in Figures 15-24 and 25-29 respectively.

What follows are descriptions of the three alternate flow control valves referred to above. In describing these alternate embodiments, elements which correspond to elements described above in connection with the embodiment of Figures 1-11 will be designated by corresponding reference numerals increased by one hundred, two hundred and three hundred, respectively. Elements of the alternate embodiments having no counterparts in Figures 1-11 will be designated by odd numbered reference numerals. Unless otherwise specified, the alternate embodiments are constructed and operate in the same manner as the flow control valve 16 of Figures 1-11.

Referring to Figures 12-14, a flow control valve 116 includes a generally triangular-shaped body 154 having an upper surface 156 and a lower surface 158. In order to rigidify the valve body 154, the lower surface 158 is provided with peripheral ribbing 159 extending from one side of a fin-like handle 160 (which could be rendered expendable by the ribbing 159) to an opposite side thereof, as well as a central rib 161 bisecting the peripherally ribbed portion of the lower surface 158 into two sections 163. The enhanced rigidity of the valve body 154 ensures that the flow control valve 116 will pass the most stringent small parts tests, such as those required in the United States and Canada, which have been promulgated to prevent the sale of products having parts that can easily become lodged in an infant's throat.

As a further safety means, the flow control valve 116 is provided with a pair of holes 165, one in each of the sections 163. Each of the holes 165 can function as an emergency air passageway in the event that the flow control valve 116 becomes lodged in a user's throat. The holes 165 may also be sized and shaped to receive the rack pins of an automatic dishwasher.

With reference now to Figures 15-24, a flow control valve 216 includes a generally triangular-shaped body 254 having an upper surface 256 and a lower surface 258. A retaining strap 259 is pivotally attached to one side of the valve body 254 by a living hinge 261 (see Figures 18 and 21). If the retaining strap 259 is made from a sufficiently flexible material, the living hinge 261 may be eliminated.

The retaining strap 259 has a fin-like handle 260, which depends from an upper surface 263 of the retaining strap 259. A tapered plug 265, which will be described in

greater detail below, depends from a lower surface 267 of the retaining strap 259. The plug 265 has a plurality of snap beads 269, whose function will be described hereinafter, and a plurality of cutouts 271, whose function will also be described hereinafter. While three snap beads 269 and three cutouts 271 are depicted, it should be understood that their number could be reduced or increased within practical limitations.

The lower surface 258 of the valve body 254 is also provided with a plurality of cutouts 273, which cooperate with the cutouts 271 in a manner to be described hereinafter. The cutouts 273 communicate with a passageway 276 provided in a nipple 264 projecting from the upper surface 256 of the valve body 254. The passageway 276 includes a circular groove 275 (see Figures 21 and 22), whose function will be described below.

Before inserting the flow control valve 216 into a cap, such as the lid 14 of Figures 1-11, the handle 260 can be gripped to pivot the retaining strap 259 about a pivot axis defined by the living hinge 261 until the plug 265 is inserted into the passageway 276 in the valve body 254. The insertion of the plug 265 is facilitated by the fact that its taper matches that of the passageway 276. When the plug 265 has been fully inserted into the passage 276 (see Figures 23 and 24), the snap beads 269 are releasably received in the groove 275, while the cutouts 271 are aligned with the cutouts 273.

In use, liquid flows around the edges of the strap 259, through the aligned cutouts 271, 273 and into the passageway 276 of the nipple 264. The liquid is then discharged from the nipple 264 through a slitted diaphragm 272, which operates in the same manner as the diaphragm 72 of Figures 1-11. The retaining strap 259 promotes proper operation of the diaphragm 272 by performing a damming function which deflects the

flowing liquid so as to protect the diaphragm 272 from excessive pressure surges that could be produced if the liquid were allowed to impact the diaphragm 272 without first being deflected. During a feeding operation, the cutouts 271, 273 create a siphoning effect that maximizes liquid evacuation.

At the conclusion of a feeding operation, the handle 260 can be gripped and pulled, thereby dislodging the plug 265 from the passageway 276. The flow control valve 216 may then be removed from its associated cap. Of course, before dislodging the plug 265 and removing the flow control valve 216, it would be necessary to detach the lid from its associated cup. The ability to dislodge or remove the plug 265 from the passageways 276 makes the flow control valve 216 easier to clean.

Referring to Figures 25-29, a flow control valve 316 includes a generally triangular-shaped body 354 having an upper surface 356 and a lower surface 358. In order to rigidify the valve body 354, the lower surface 358 is provided with peripheral ribbing 359 extending from one side of a fin-like handle 360 (which could be rendered expendable by the ribbing 359) to an opposite side thereof, as well as a central rib 361 bisecting the peripherally ribbed portion of the lower surface 358 into two sections 363. The enhanced rigidity of the valve body 354 ensures that the flow control valve 316 will pass the most stringent small parts tests, such as those required in the United States and Canada, which have been promulgated to prevent the sale of products having parts that can easily become lodged in an infant's throat.

As a further safety means, the flow control valve 316 is provided with a pair of holes 365, one in each of the sections 363. Each of the holes 365 can function as an

emergency air passageway in the event that the flow control valve 316 becomes lodged in a user's throat. The holes 365 may also be sized and shaped to receive the rack pins of an automatic dishwasher.

As can be appreciated, the foregoing features are common to the flow control valve 116 of Figures 12-15. The flow control valve 316 does, however, employ additional features which are not common to the flow control valve 116 or to any of the other flow control valve embodiments described above. These additional features will be described hereinbelow.

The handle 360 includes its own peripheral ribbing 367 for the purpose of rigidifying the handle 360. The peripheral ribbing 367 also makes the handle 360 easier to grip and therefore replaces the ribs 162 employed by the handle 160 of the flow control valve 116 (see Figures 12-15).

The upper surface 356 of the flow control valve 316 includes a semicircular collar 369 which extends more than half way around a nipple 364 forming a semi-circular trough 371, whose function will be described hereinafter. A pair of arcuate slots 373 is provided in the bottom of the trough 371 on opposite sides of the nipple 364. Each of the slots 373 extends from the upper surface 356 of the valve body 354 to a lower surface 358 thereof for a purpose to be described hereinafter.

Referring now to Figures 30 and 31, the flow control valve 316 is especially adapted for use with a lid 314, which is identical to the lid 14 of Figures 1 and 2 except that it includes a pair of arcuate tabs 375 on a lower edge 350 of an internal, tubular sleeve 348. The size and shape of the tabs 375 are complementary to those of the slots 373 in the flow

control valve 316. Thus, when the flow control valve 316 has been assembled on the lid 314, the tabs 375 extend through the slots 373 (see Figure 31) to provide a visual and tactile indication that the flow control valve 316 has been properly and completely inserted. The size and shape of the tabs 375 and the slots 373 can be varied, as long as they are complementary to each other. For instance, the tabs 375 could be in the form of round pins or posts, while the slots 373 could be in the form of round holes.

The tabs 375 also cooperate with the slots 373 to increase the interference contact between the valve body 354 and the lid 314, thereby reducing the possibility that the flow control valve 316 maybe inadvertently dislodged from the lid 314. The interference contact between the valve body 354 and the lid 314 is further increased by the collar 369, which frictionally engages the outer surface of the sleeve 348 when the sleeve 348 has been inserted into the trough 371 between the collar 369 and the nipple 364.

It will be understood that the embodiments described herein are merely exemplary and that a person skilled in the art may make many variations and modifications without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention as defined in the appended claims.